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ABSTRACT

This document discusses how students and schools can benefit from exchanging computer-aided design/computer-aided manufacturing (CAD/CAM) files over the Internet, explains how files are exchanged, and examines the problem of selected hardware/software incompatibility. Key terms associated with information search services are defined, and several communication services (including electronic mail, online discussion groups, and multimedia information services) are described. The specific procedures for connecting to the Internet in the following ways are detailed: making a direct connection, connecting through someone else's gateway, using a direct service provider, and using an indirect service provider. The unique characteristics of CAD/CAM files are listed along with minimum hardware and software required to transfer them. The following potential benefits to students of exchanging CAD/CAM files via the Internet are discussed: contacting experienced and expert individuals in diverse fields, building teams across geographic distance, and accessing archived information. Common hardware and/or software incompatibility problems that may be encountered during attempts to exchange CAD/CAM files and ways of resolving them are illustrated through the example of a project to exchange files between Berea College and Morehead State University in Kentucky. Contains 11 references. (MN)

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Schools (students) exchanging CAD/CAM files over the Internet

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The purpose of this paper is to explain what is necessary for schools (students) to exchange Computer Aided Design/Manufacturing (CAD/CAM) files over the internet. Most colleges and universities currently have access to the internet. Many of the middle and high schools in the nation have also come on-line. In fact, all of the 176 school districts in Kentucky are now linked to the internet (May, 1995, p.B1). The internet is a resource of which educators need to take advantage. Not only getting students searching for information on the World Wide Web or communicating through e-mail, but more importantly to get students from different schools working together on activities or projects. Or perhaps developing an industry-education partnership for a joint activity. The opportunities presented by access to the internet for teachers and students are endless and with some creativity can result in tremendous learning experiences.

This paper will explain one activity that can be conducted on the internet. The objectives of the paper are to help you:

1. develop an understanding of how to exchange CAD/CAM files over the internet,
2. learn about the hardware and software needed for this activity,
3. realize the many benefits for your students,
4. be enlightened as to costs, successes and problems with exchanging CAD/CAM files over the internet,
5. learn some instructional strategies for exchanging CAD/CAM files over the internet.

The internet, also known as the Net, has been described as a collection of thousands of computer networks, tens of thousands of computers, and more than 10 million users who share a compatible means for interacting with one another to exchange digital data (Tolhurst, 1994).

One of the primary goals of this project is to use the internet as a means of communications, therefore one must examine the options available. The internet is comprised of four main services; information retrieval services, information search services, communication services, and multimedia information services (Pike, 1995). Most users associate these services through specific applications or software commonly used to access the service. Examples and a brief description of each follow. Information retrieval services would include FTP (file transfer protocol) and Gopher . The FTP servers allow the user to upload and download files. This is an example of a client-server system (Pike, 1995). The program on your local computer is referred to as client software. Client software allows the user to talk to a remote computer, a server, equipped with the appropriate software. With permission, the user would log on to the server, and then be able to download games, utilities, graphics. etc. (Engst,1993). If the FTP server gives access the user could upload files as well (Pike, 1995). Some of the advantages include ease of use, file types can be

transferred as is, and large files can be transferred. Gopher is a means of locating files and identifying the FTP site where the file is located.

Typical terms associated with Information search services include WAIS, Archie, and Veronica. WAIS (Wide Area Information Servers) differs from Gopher in the way they search. While the Gopher will search for a particular file, the WAIS will search for all documents that pertain to the search subject. WAIS is a system that searches by subject through documents on servers all over the world. There are many WAIS servers. When conducting a search, your subject is matched against key words on the WAIS server. The addresses of the matches are returned to you. Another advantage of the WAIS system is it's ability to search other WAIS servers for the topic (Pike, 1995).

Common communications services include e-mail, Telnet, UseNet, IRC and the recent development of internet phone and CU-SeeMe. E-mail is one of the oldest and most used services on the internet (Pike, 1995). It allows the user to send and receive mail electronically. E-mail is a fast and inexpensive method of communication (Engst,1993). One drawback of e-mail is related to the age and history of the service. Since it was originally designed for text communications it transmits a seven bit, or ASCII word. This limits the user to text only files (Heid,1994). To overcome this limit, programs have been written that transform binary or eight bit files into ASCII files just for transmission over e-mail. Once the file is received, it must be transferred back into original form to be used (Pike, 1995). With the demand for this feature, newer formats have been devised to make the task painless. Telnet allows the user to connect to a remote computer and setup and run programs on that computer. UseNet is the service that allows for newsgroups. These online discussion groups cover thousands of topics. IRC (Internet Relay Chat) allows multiple users to talk (type) simultaneously (Pike, 1995). Most of the IRC programs will support file transfer. This allows the user to chat, exchange files and discuss the files that were just sent. Internet phone is software that allows the users to call and talk to each other over the internet. The internet serves as the carrier, so there is no additional cost. Programs such as IPhone and NetPhone are two of the more common ones. CU-SeeMe was developed at Cornell, it allows for both audio and video communications over the internet. The software and information is available from http://cu-seeme.cornell.edu/.

The multimedia information services would include the WWW (World Wide Web). The WWW allows the user to navigate through and view documents anywhere on the Internet. Text, graphic, sounds, etc. can be viewed while on the net. It also allows for the other services previously mentioned to be accessed. Examples would include Mosaic and Netscape.

There are basically four ways to connect to the internet. They include:

1. a direct connection,
2. connecting through someone else's gateway,
3. a direct service provider, and
4. an indirect service provider.

Choosing which method will most likely be determined by availability and cost (Pike, 1995). To make the choice that is best for your situation a knowledge of the four options is necessary.

The direct connection uses a dedicated machine connected into the internet backbone. This method allows full access to all internet services but is expensive and time consuming to maintain. The cost limits this method to large enterprises. The second method is to connect through someone else's gateway. Permission of the gateway's owner must be obtained. This type of connection is usually limited to students and employees of the enterprise. The direct service provider method, sometimes called internet service provider ISP, involves a company with a gateway that provides limited or unlimited access to the internet. This type of company differs from online services in that they only provide access to the internet. Connections are made through modems or dedicated phone lines. The final method is using an indirect service provider. The user would use an online server such as eWORLD, CompuServe, etc. The online servers will provide limited or total access to the internet along with the other services they provide (Pike, 1995).

Although successfully exchanging CAD/CAM files over the Net may prove to be quite simple for those with huge financial resources and the proper connections, it is much more difficult for others. Many, if not most, of the industrial community involved in exchanging such files have access to communication lines with large band widths such as T-1 or T-3. Bandwidth determines the volume of information that can be sent over a network in a specific time period. The T-3 line is the backbone of the U.S. internet system and can transfer data at 45 Megabits per second (Mbps). The T-1 line can transfer data at 1.5 Mbps. (Levine, 1993). As you can imagine this makes the process of exchanging huge CAD/CAM files, or any file for that matter, very simple.

A recent discussion with a former student revealed the following information. He is employed by a company that has three plants in North America. The company leases a T-1 line from Netsolve Corporation for around $2,500 per month. With this kind of resource it is easy for the company to transfer huge CAD files in a matter of seconds. It is believed that most industrial facilities use a similar method for data transmission. But what about those who may not be connected to the internet via the T-1 or T-3 lines. Data transmission is a little more difficult.

CAD and CAM files are 8-bit binary files and unless you are doing a File Transfer Protocol (FTP) they can be difficult for the average user to transfer. The reason is because the mail transport programs on the internet were originally set up to transmit ASCII (7-bit) data only and it

continues to be that way today. Therefore, to successfully transmit CAD/CAM or any binary file they must be converted to 7-bit for transmission. The receiver would then need to convert the file back to 8-bit in order to view it properly. If you are not careful you may lose some of the data in the transmission. It is assumed that most educators will be transferring CAD/CAM files over the internet using a mail transport program (e-mail). Several techniques to successfully transmit binary files will be discussed later in this paper.

There are many reasons why you might want to get students involved in exchanging CAD/CAM files over the internet. First, and most obvious, is just to get students interested in working with the Net. Once you have piqued their interest students can:

1. exchange information quickly and conveniently,
2. access experienced and expert individuals in thousands of fields,
3. receive regular updates on topics of interest,
4. gain wide-area access to your data,
5. build teams and enhance teamwork across geographic distance,
6. gain access to archived information,
7. translate and transfer data between machines,
8. have fun and be entertained (Tolhurst, 1994, p.8).

Students might get involved in a industry-education partnership to simulate a real-world project. Or perhaps a group of secondary students could work on a project exchanging files with students from a college or university. In addition to building teams and enhancing teamwork across geographic distances, students will learn to use new technology to achieve a task. Using your imagination could create many possibilities for a variety of activities.

Many disciplines are currently using the internet to enhance their subject matter. Although much of the use centers around e-mail and research to find information, there are other activities taking place. Such endeavors as the Boulder Valley Internet Project (Black, et. al., 1995, p. 54) and the efforts at Eagan High School in Minnesota (Wilson & Utecht, 1995, p.75-79) reveal several activities that involve students using the internet.

Although there are probably many techniques for successfully exchanging CAD/CAM files the way you do it may be determined by your access to the internet. As explained earlier if you have access to a T-1 or T-3 line for data transmission you should have little problem exchanging large binary files in a matter of seconds.

It is believed that most of our readers will be exchanging binary files over the internet using some kind of mail transport program (e-mail). The project between Berea College and Morehead State University (MSU) has been to experiment with this technique for data transmission of 8-bit (binary) files. There are many things that need to be considered when exchanging CAD/CAM files from one geographic

location to another. For example, are the systems at both locations compatible, not only the hardware but also the software? Don't be discouraged if your systems are not exactly compatible. You can still transfer the data it just may be a little more difficult and require a little more effort on your part. The ideal situation would be for each system to be compatible. An example would be both the sender and receiver using a Macintosh computer or both using an IBM compatible PC. The same CAD package and version would be nice (i.e. Autocad v.12). The same encode/decode software would be helpful (i.e. wincode or xferpro). However, let's face it, this is not likely to happen.

In the project between Berea and MSU there were many differences in both hardware and software. Here is an example of some of those differences:

	Berea	MSU
micro-computer:	Power Mac	IBM Compatible PC
e-mail package:	ccMail	Pine
encode/decode software:	Wincode	xferpro
compression software:	Stuffit	PKZIP
CAD software:	Autocad v.13	Autocad v.12
CAM software:	MasterCam	SmartCam
Mainframe Operating software:	Mac	Unix
Mainframe encoder:	BinHex	Mime

As you can see, we were almost doomed from the beginning. Nonetheless, we were still able to successfully transmit CAD/CAM files over the internet.

Regardless whether you are compatible or not there are certain things that need to be done to successfully transmit binary data. You need to understand that 8-bit files have to be changed to 7-bit files. This is often referred to as uuencoding and is a process of sending binary data through e-mail. This process is usually done with a program such as uuencode, wincode, xferpro or another conversion software package. Versions of uuencode are available for free on the internet. This software will encode the binary data as a series of printable ASCII characters. In other words, it will change your 8-bit file to a 7-bit file which can then be transmitted over the internet by your e-mail program. After you translate your binary file into ASCII data you can include it in the text of your e-mail message or as an attachment to your message. The attachment method seems to work the best. The receiver on the other end will need to decode the file using a encode/decode software. This will extract the proper .dwg CAD file or the .dxf CAM file. At that time you can bring it into your CAD or CAM software program for viewing.

Some host computers will automatically encode a binary file before sending it via e-mail. Early on in our project it was unknown that the files were automatically being encoded by the university mainframe computer. We would encode the file, attach it to the e-mail and send it. It would then get encoded again as it left the college or

university. This created a minor problem because the file would then need to be decoded twice in order to extract the proper drawing file. Once this was discovered we simply began attaching CAD (.dwg) files to our text message. An example would be a file sent from Berea College to MSU. The original file is test.dwg, however, as it leaves Berea the encoded file becomes test.uue. The test.uue file arrives at MSU. The text is easily read, but of course the binary file makes no sense. The heading on the binary file reads "This file must be converted with BinHex 4.0" which indicates the file was encoded. The file is decoded with a software package called xferpro that is capable of decoding a variety of different binary files. Again , many of the conversion software packages are available for free on the internet. You simply need to locate and download them to your computer. The drawing file (.dwg) is now ready to be viewed in the proper CAD package. It is most appropriate when sending encoded binary data to always include information in the text message that tells the remote user what the data was originally. You should also include information on what method was used to encode the data as well as anything else that will assist the receiver.

The above process describes a difficult process for a simple task, it is a worse case scenario. If you have an older e-mail system you can exchange files just as described. However, there is a demand for the transfer of files and this has changed the standards. One cross platform e-mail program is Eudora. It will allow Macintosh and IBM users to exchange files as attachments. Since both the Mac and PC versions of the software were written by the same company they recognize the encoding and compression formats. In application the sender simply attaches the file and the receiver opens the attachment. The software takes care of all the encoding and compression related tasks.

If a mail transport program (e-mail) is your only means for exchanging binary files, what has been described here should work. However, there are other techniques that work as well or even better. Probably the easiest and most common way of transferring binary files is to use the File Transfer Protocol (FTP). This technique enables you to log in to a remote computer on the internet, look through its subdirectories, and download either ASCII or binary files that you may desire. For this project we were able to establish a FTP site at Berea College so that CAD files could be placed at the site and easily downloaded by MSU students. This worked very well. The biggest problem we encountered was getting the approval to set up the ftp site. Information technology personnel at both universities were a little nervous because of security reasons. Those connecting to the ftp site would also have access to other information on the remote computer.

Internet Relay Chat is another method that can be used to exchange files. It has the added benefit of allowing the students to discuss the drawings and identify problems or

clarify questions immediately. To exchange files by this method, the students connect to a server, meet on a channel (chat room), and send and receive files through DCC (direct client to client) send and get commands. Typing to talk is very awkward at first, but it is easy to watch both speed and proficiency improve. If typing is a hurdle IPhone or CU-SeeMe can be used in conjunction with IRC. This allows for file transfer, but gives the added feature of voice or video.

There are many instructional strategies that could be used to get students exchanging files over the internet. The strategy for the Berea/MSU project was to have students exchanging files in a joint effort to design and construct a desktop CIM cell. Students were instructed that all communications for the project were to be done over the internet. Internet tools were used for communications and file transmissions.

Design briefs were developed for the basic building block and a robot end effector. The basic building block was designed by MSU students and sent to Berea. Students at Berea cast the part and sent it back to MSU for final machining. This utilized resources at both institutions. Berea has the foundry resources and MSU has a machining center. Berea also has a turning center that was used in machining the end effector.

A similar instructional strategy could be developed to involve middle and high school students exchanging CAD/CAM files with each other or with a college or university. Another strategy would be to have students do research and make a presentation which would include information received over the Net.

There also appears to be a great potential for education/industry exchange. Students could get involved in a real-life project with a local or remote industry that would involve exchanging text and binary files. This could prove to be valuable and beneficial to both parties.

The project between Berea College and Morehead State University students has been challenging, exciting, and fun. Although it will be several months before the CIM project is completed, things are moving rather well. With a limited number of students involved only a few components for the CIM cell will be designed and fabricated at this time. Eventually we hope to involve more students communicating over the internet both for their benefit as well as completing the project. Initial feedback from the students involved has been positive and we believe the project has already been a success.

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